ARBORICULTURAL ASSESSMENT

For

TAINUI AND TAUROA RESERVES

PREPARED BY

PAPER STREET TREE COMPANY

• MANAGEMENT RECOMMENDATIONS •

REPORT COMMISSIONED BY:	Hastings District Council
REPORT DATED:	26.08.21
PROPOSAL:	To provide arboricultural management recommendations for the two reserve areas

EST. PS 2013

ARBORICULTURE CONSULTANCY

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EXECUTIVE SUMMARY

Both sites have ageing plantation trees which are being proactively removed, along with revegetation works being carried out in partnership with the community.

Tainui has a historical site of significance where plantation species are impacting the site and cultural values.

Analysis was carried out on 1,758 recorded items to inform management recommendations.

Given the cultural significance of the site, history of tree failure, tree and site conditions, the removal of 514 trees is recommended (433 from Tainui and 81 from Tauroa). Further recommendations for mitigation are also included to improve landscape resilience and benefits for both reserves.

Providing the recommendations are carried out, the long-term benefits will surpass that of the current canopy coverage whilst significantly improving cultural wellbeing and allowing for greater community partnership opportunities.

Richie HIll

1 INTRODUCTION

1.1 I have been engaged by Hastings District Council to provide arboricultural management recommendations for Tainui and Tauroa Reserves in Havelock North.

1.2 The recommendations are based on site observations, survey details (carried out between June and July of 2021) and on reviewing current plans and policies (Tainui Tanner Tauroa and Hikanui Reserves Management Plan 2015).

1.3 The purpose of this report is to summarise those findings, build on existing strategies and provide recommendations to support sustainable outcomes for the two reserve areas.

1.4 ***Layout of the assessment***

The report is set out as follows:

2. Performance summary of trees captured

Summarises the survey information

3. Risks and management

Processes the site information and identifies risks and management opportunities

4. Recommendations

Provides recommendations based on the analysis

5 Sustainable Development Goals (SDGs)

Assessing the recommendations against the relevant SDGs

1.5 The 2015 Management Plan provides a good overview of the tree stock and the management objectives to progressively replace the ageing forestry with indigenous planting for ecological restoration. This has involved:

- Proactive removal of ageing forest species and managing any risks
- Large scale planting
- Pest species control

The aim of this assessment is to provide sustainable management action to support those objectives and to build on existing details. For further information on the background of the site, the 2015 management plan provides a good overview (Tainui-Tauroa-Tanner-Hikanui-RMPlan.pdf (hastingsdc.govt.nz)).

1.6 *Assessing information to achieve objectives*

Paper Street Tree Company Ltd (PS) supports the Sustainability Development Goals (SDGs). The Sustainable Development Goals provide a framework to build greener, stronger and more resilient societies.

1.6.1 There is a growing body of research documenting the benefits of the close integration of trees with society. These include buffering heat extremes, slowing rainwater runoff, reducing air pollution, sequestering carbon, economic benefits and improving human health and wellbeing.

1.6.2 Competing land needs, management activities, development intensities, and climate change place increasing uncertainty on the sustainability of the urban ngahere (forest). This is at a time when public aspirations for more trees is increasing. Therefore, adaptation, collaboration and partnerships across external and internal disciplines are essential to improve the sustainable management of the urban tree resource.

1.6.3 Therefore, the SDGs provide a measure to ensure recommendations allow pathways to meet that end, to build greater resilience within the urban ngahere.

SUSTAINABLE DEVELOPMENT GOALS

"Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs."

2 PERFORMANCE SUMMARIES OF TREES CAPTURED

2.1 *Site survey*

The site survey recorded 1,758 items between the two reserve areas, to inform management analysis. These items were all mapped to quantify the data to support management recommendations.

In general, all trees were inspected that had the potential to cause harm or damage or to affect objectives. If a tree had the potential to cause harm or damage or affect objectives, it was recorded, and the item was mapped either as an individual item or as a group. The majority of trees recorded were to inform the analysis. This involved capturing an area of newly planted revegetation to provide objective analysis.

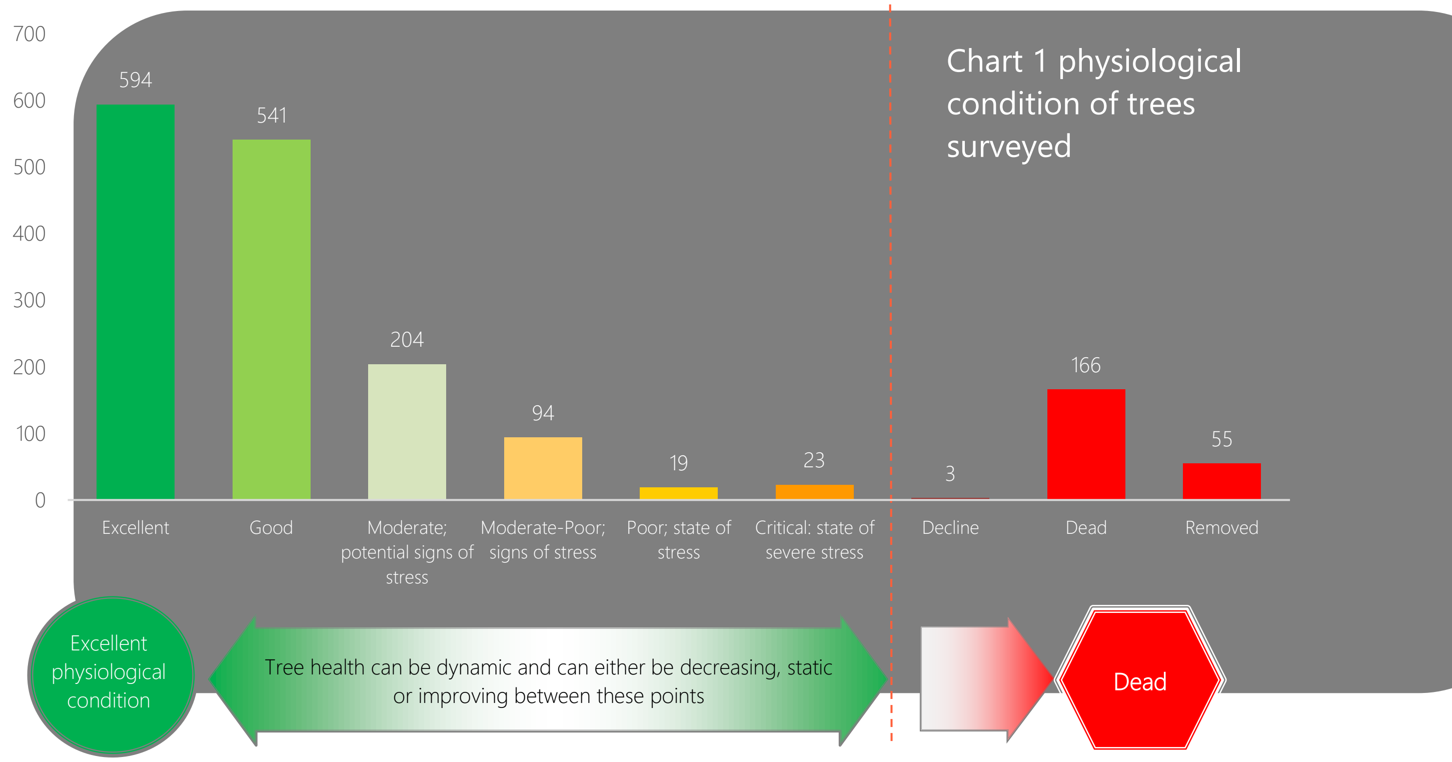
2.2 *The extent of the survey*

The survey method used records: tree species, diameter and height ranges, average canopy spread, species life stage, history of failure, and any management requirements. Data captured from mapped trees informs the management recommendations. Risk management (ISO31000), asset management principles (ISO55002) and site objectives underlie PS management recommendations set against SDGs.

Fig.1 Items captured.

2.3 *Tree physiological function (tree health)*

Tree health is essential for tree function, reaction to stressors, and for the delivery of ecosystem services (the benefits we receive from trees). Below is a summary of the current health of the 1,758 trees assessed.



2.4 *Climate change*

Climate change predictions for the region are for temperature increases and extended periods of prolonged dry weather decreases in rainfall and alter the intensity of and frequency of winds and fire.

"Climate change-induced hazards, such as changes in the temperature, rainfall and CO2 concentration, could impact natural and modified forests substantially (Kirilenko and Sedjo, 2007, FAO, 2018). The possible impacts of climate change on forests include, but are not limited to, shorter or longer growing seasons, modifications in the forest's biodiversity including its macro and microbiota, changes in the pests and disease factors and their spread pattern" (NIWA 2020)

2.4.1 It is difficult to determine the impact of climate change will have on the urban ngahere, but given current modelling and predictions, increasing change should be expected, which is likely to affect the following areas within the reserve:

- The establishment of new trees, especially for species that are sensitive to drought in juvenile stages (e.g., most climax native species)

- Stress and potential decline for trees that sit on the edge of their climate tolerance for the region

- Possible erosion on bank edges from extreme rainfall events

- Increase in weed species (more suited to climate adaptation)

- Possible increase of pest and diseases

- An increase in CO_2 may increase the growth rate of plantation species to grow taller and more slender and more prone to wind damage (Watt et al., 2019). But also favourable for weed species (so the rate of growth colonisation could increase)

2.4.2 These effects can be seen within the stand of trees that are located near the pā site, as discussed in the following sections.

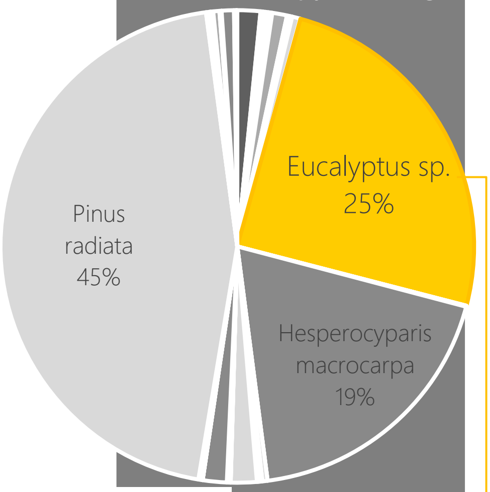
2.4.3 The images below are of Tainui overlooking the pā site taken in 2016 and 2020.

Fig.2 Aerial image of Tainui Reserve pā site 3/9/2016 (Google Earth)

Fig.3 Aerial image of Tainui Reserve pā site 2020

2.4.4 The resolution of the 2020 image is of higher quality. However, changes in canopy health can still be observed. Gaps in the canopy are also visible from failures, which would be expected given the makeup of the stand on the pā site (ageing plantation stand). Most of the canopy coverage in this area is made up of three species: Monterey pine (*Pinus radiata),* macrocarpa ((*Hesperocyparis macrocarpa),* and eucalyptus (*Eucalyptus sp.)* see chart 2.

Chart 2 Canopy coverage



2.4.5 In the two aerial images, eucalyptus trees show the most change in foliage density since the 2016 image below (fig 4) shows the mapped eucalyptus trees, with corresponding chart (chart 3) showing eucalyptus tree health of the eucalyptus trees.

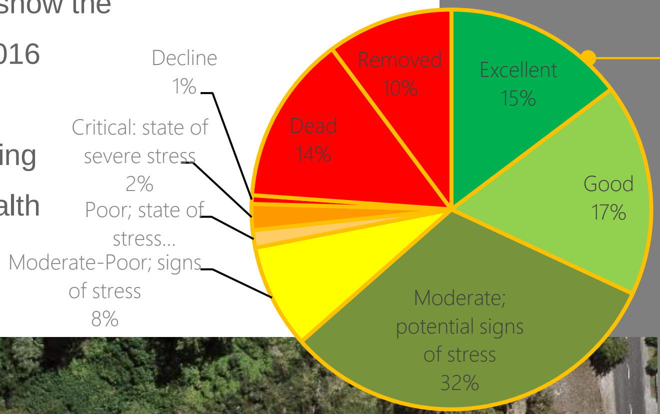


Chart 3 Eucalyptus tree health

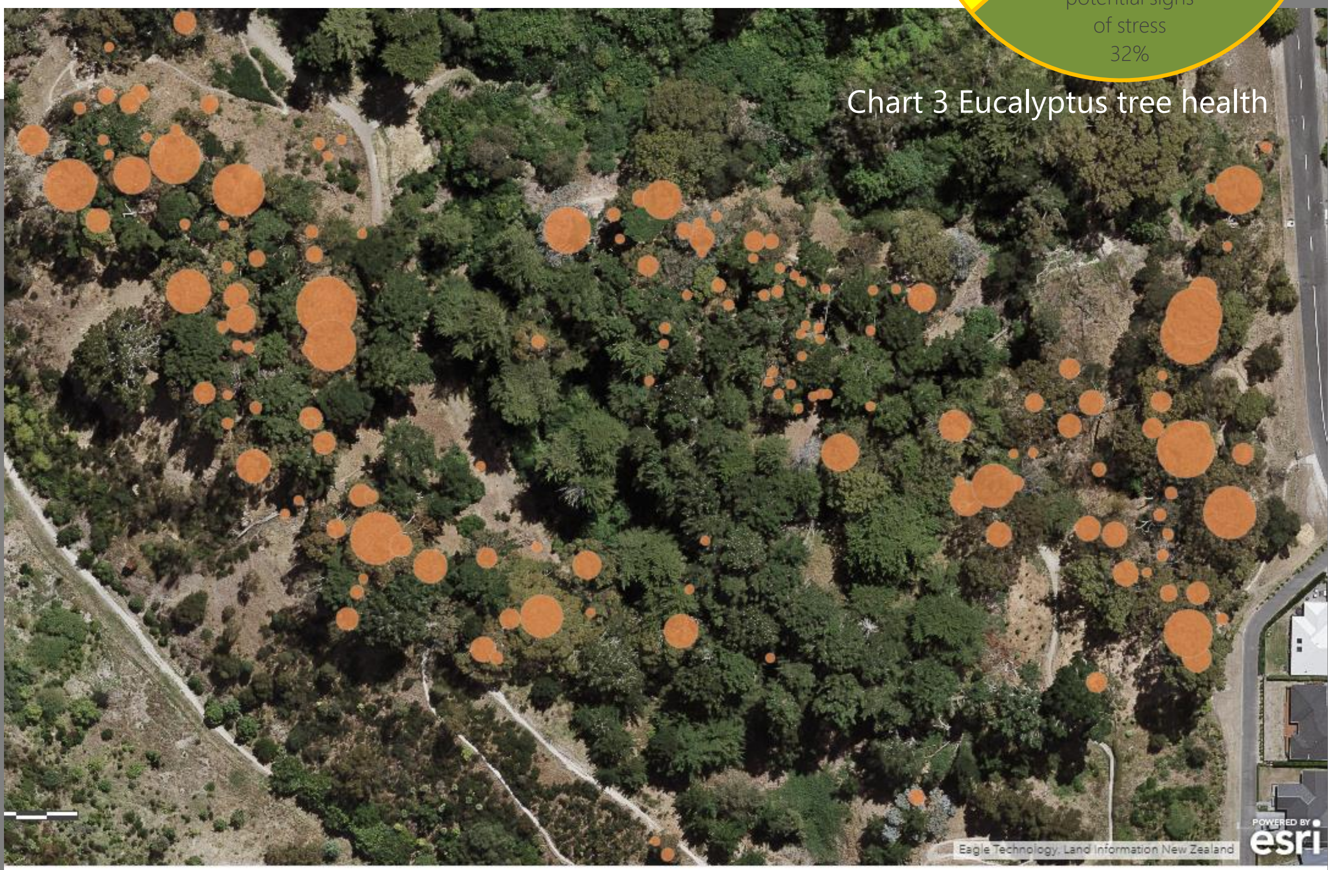


Fig. 4 Location of all eucalyptus trees surveyed (size of the circle provides an indication of tree size)

2.4.6 Eucalyptus is a genus of over 900 species. Around 240 species have been introduced into New Zealand (Ecroyed 2010). These trees come from a range of climatic regions, where certain species have limited tolerance to prolonged dry periods, mainly the stringybark and ash eucalyptus (Florence, 1996). The area has had a couple of years of prolonged periods of dry conditions, which is likely to have contributed to the trees' current conditions. Another contributing factor to trees being in a state of stress is from pest species (figs.5 & 6):

- **Bronze bug (*Thaumastocoris peregrinus*)**
  The bronze bug is a serious pest for eucalyptus, first recorded in Australia and spreading to 15 countries (BiCEP), including New Zealand. *T. peregrinus* has been reported to affect up to 40 eucalyptus species, with certain species showing more susceptibility to infection e,g, *Eucalyptus scoparia* and *E. nicholii*). The lifecycle of *T. peregrinus* is 30-60 days, and due to the high reproductive potential of the species, rapid population increases are possible, particularly when optimum conditions for growth and survival are present. Serious infestations of the bronze bug can cause defoliation, branch dieback and, in some cases, tree mortality.

Fig. 5 Bronze bug

- **Brown lace lerp (*Cardiaspina fiscella*)**
  C. fiscella is another serious Australian pest (fig.6), especially for *E. saligna* and *E. botryoides*. Once again, the brown lace lerp is a sap feeder where a severe infestation can cause defoliation, branch dieback and, in extreme cases, tree mortality.

Fig.6 Brown lace lerp

2.4.7 As the health graph for eucalyptus shows (chart 3), some trees within the site exhibit signs of stress, whereas others show good physiological conditions. This will be down to the genetic tolerances of the species and the localised environmental stressors they are subjected to.

Fig. 7 Note the differences in canopy health within gum stand

2.4.8 The region has been subjected to a few years of prolonged periods of dry weather, as highlighted in section 2.3.2. These conditions are predicted to become more typical. Most trees will adjust their leaf area to conserve water in response to prolonged dry conditions. As shown in graph 1, tree health can be very dynamic.

2.4.9 Eucalyptus will compensate for reduced leaf area by increasing leaf thickness to make up for the photosynthetic loss (Farquhar *et al.,* 2002). Sap feeding insects are reliant on plant turgor (osmotic pressure). During low rainfall periods, as plant stress increases, the ability of a tree to produce natural defences against such pests becomes impaired, resulting in increased infestation rates (Wills & Farr 2016).

2.4.10 Further outbreaks or infestations are likely for certain species which are susceptible to infection, given the climate predictions for the region.

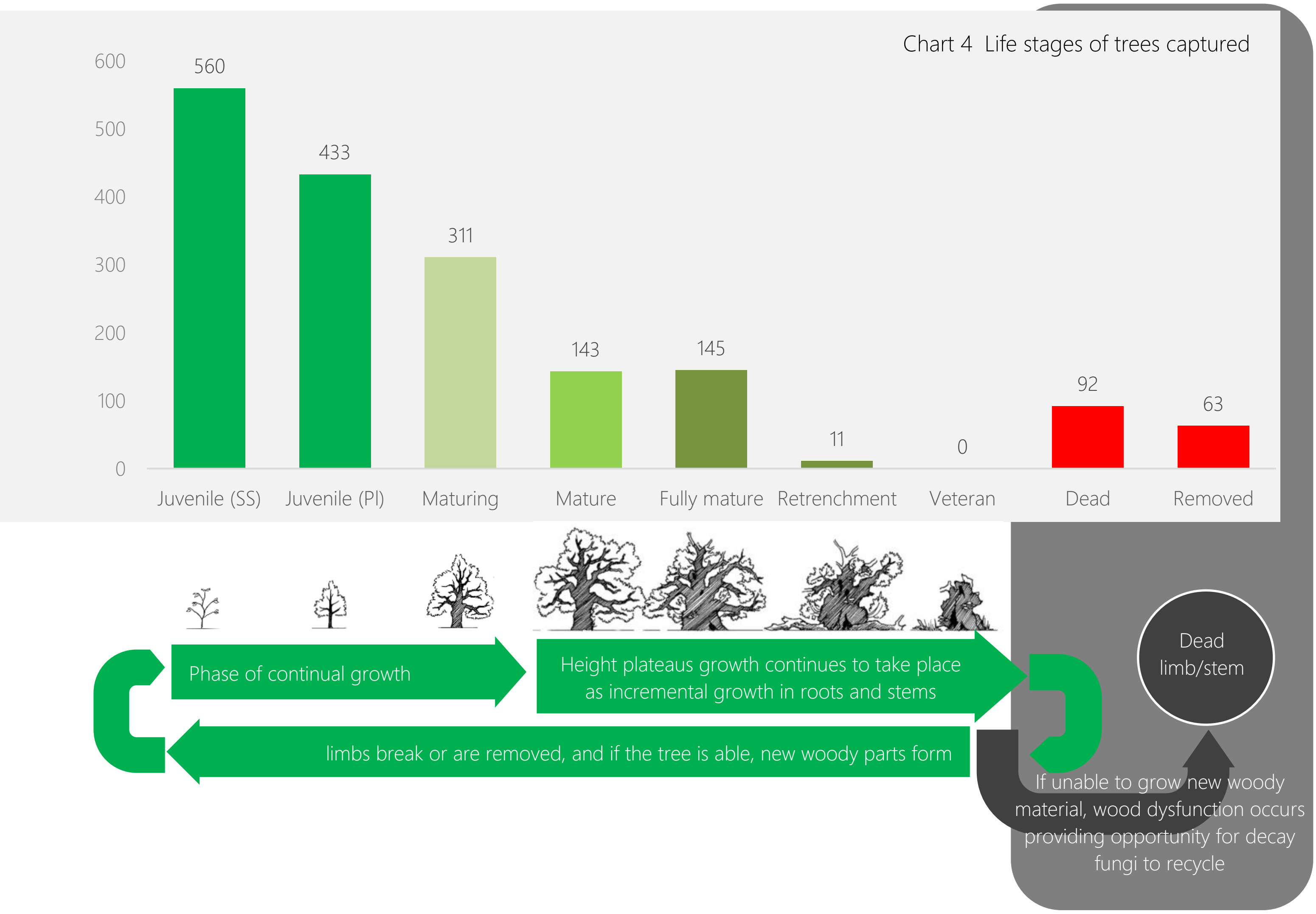
2.5 *Assessed trees by current life stages*

Trees don't enter senescence as such (the declining division and growth of cells that inevitably results in ageing and death), whereas trees continue to form new organs and tissue, e.g. reiterate (resprout), lay incremental growth (a continuous division of the vascular cambium)).

Studies have shown cells in 600yr old trees are no different to cells in their 20yr old counterparts, where they continue to retain strong resistance to external stressors (disease and produce protective functions).

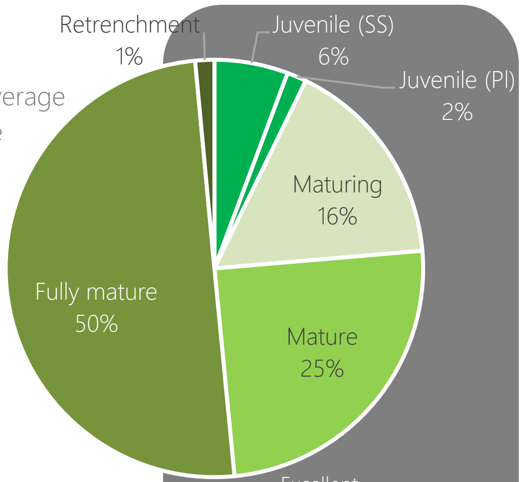
Trees can live for hundreds if not thousands of years. The genetic characteristics of species and the environmental stressors (biotic or abiotic) to which a tree is subjected are the primary causal factors for tree mortality.

Using a tree life stage model provides a view of the tree in terms of its standard morphological, developmental life stage to diagnose perturbations in physiology and to estimate net environmental and amenity worth.



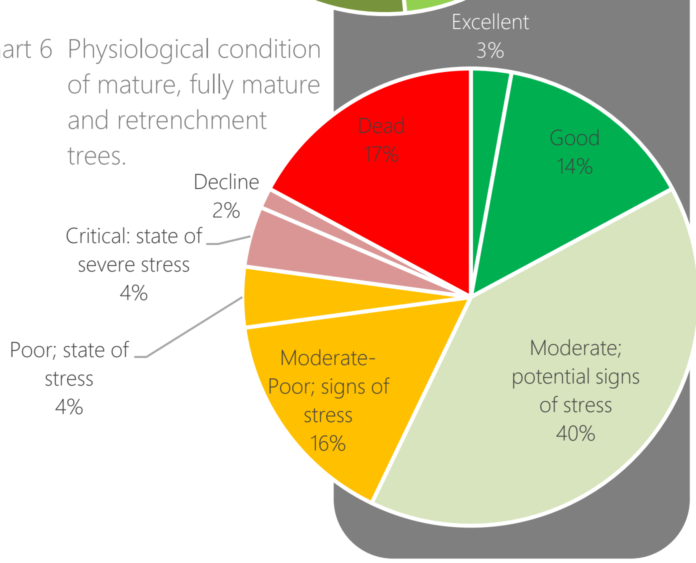
2.5.1 To put the above chart into context, Chart 5 shows the canopy coverage for life stage.

Chart 5 Canopy coverage by life stage



2.5.2 Chart 6 shows, only a small proportion of the primary canopy coverage species are in good or excellent health. This does support the observations on the aerial images that mature canopy coverage is beginning to thin, which will create opportunities for emergent vegetation. Given its abundant seed source, this would be pine (110 self-seeded specimens were recorded). However, around 240 mahoe self-seeded specimens were also recorded, which is a positive for the restoration efforts.

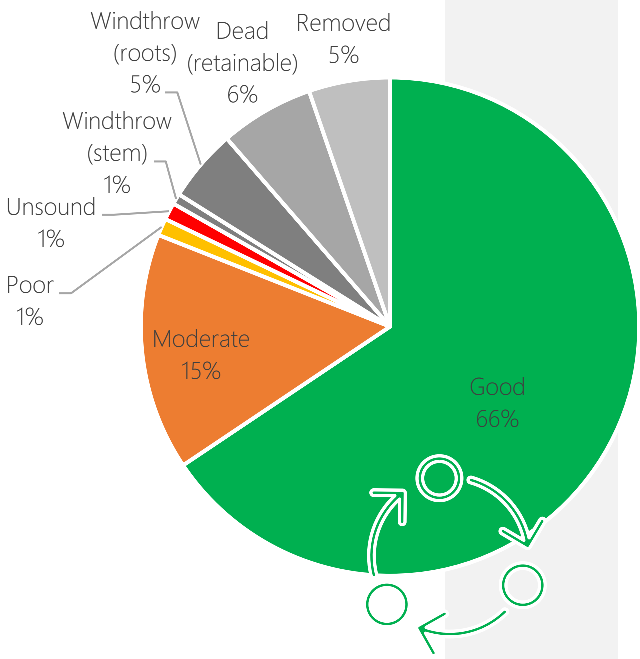
Chart 6 Physiological condition of mature, fully mature and retrenchment trees.



2.6 *Tree structure*

Chart 7 shows the structural condition of the mature, fully mature and retrenching trees. A number of the pine trees captured had diameter to height ratios around 70:1 to 85:1. Research shows that trees with a diameter ratio of 80:1 in plantations show increased susceptibility to storm damage (Wonn 2001). Trees that exceed this threshold are more susceptible to storm damage. Generally, edge trees grow thicker in diameter and shorter in height due to greater exposure to winds than trees within a stand. During a high wind event, group trees are buffeted by adjacent trees. If a tree is lost, this can have a more significant impact on adjacent trees; *(Mitscherlich 1974; Briinig 1974; White et al. 1976). Fraser (1964) observed with model forests in a wind tunnel that*

Chart 7 Structural condition of mature, fully mature and retrenchment trees.



Structural integrity is dynamic where integrity can be improving or decreasing with the objective of management intervention to move trees towards the sound end of the spectrum *the wind load per tree was doubled when the spacing between trees was increased from 25% to 40% of tree height (*Cremer 1982).

The stand of trees on the pā site and in small stands in Tauroa, trees are beginning to become more exposed. So even though the current structural condition of the trees captured is currently good, as a group, once a tree falls or is removed, the structural integrity of adjacent trees will be altered. Considering the makeup of the trees captures, the current condition may be viewed as good, but this condition is considered to be decreasing.

Therefore, it is important to look at the structural condition of the stand as a snapshot in time, as a high wind event could alter stand dynamics and the overall structural rating of trees fairly significantly if trees with high height to diameter ratios, or trees with existing defects become exposed.

2.6.1 Overall summary of structural tree conditions

The majority of the trees stand are as a grouped planting, and as such, are reliant on trees within proximity of each other for structural stability. On the whole, the majority of the trees show no obvious defects outside of what would be expected for a natural stand. But there are trees within the stand that have a height to diameter ratio that will be more susceptible to failure if they become exposed.

2.7 *History of Failure*

The following aerial image is of Tainui above the pā site. It shows where the majority of failures have occurred.

Fig.8 Location of trees failed from windthrow. The larger the circle, the greater the number of failures recorded in the location. Red dots = macrocarpa trees, blue dots = eucalyptus trees, green dots = pine trees, yellow dots = pine and eucalyptus trees, and purple dot = Sheoak.

2.7.1 The majority of failures captured were recorded along the western bank face of the pā site. 86 trees were recorded as having suffered windthrow. 67% of those failures (58 trees) were macrocarpa. 36 of the failures took place on the western bank face of the pā. The history of failure along the bank face and the conditions on site indicate the bank face is moving/slipping. The majority of macrocarpa that has failed within this area would be classed as maturing. Failure of maturing macrocarpa trees is not uncommon, especially in shallow soils such as these; this species tends to focus its root growth within the fertile layer of soil. The combination of this growth habit, the soil conditions, and the movement of the slope makes further failure more likely.

Fig.9 Macrocarpa shallow root horizon (yellow lines)

Fig.10 underside of the macrocarpa windthrown stump note the lack of vertical roots (and very flat highlighted by the yellow box) and just one large root bottom left

Fig. 11 Comparison root system of a pine – note the vertical roots around the root ball

2.8 *Cultural and wellbeing significance*

2.8.1 Positive wellbeing and amenity effects

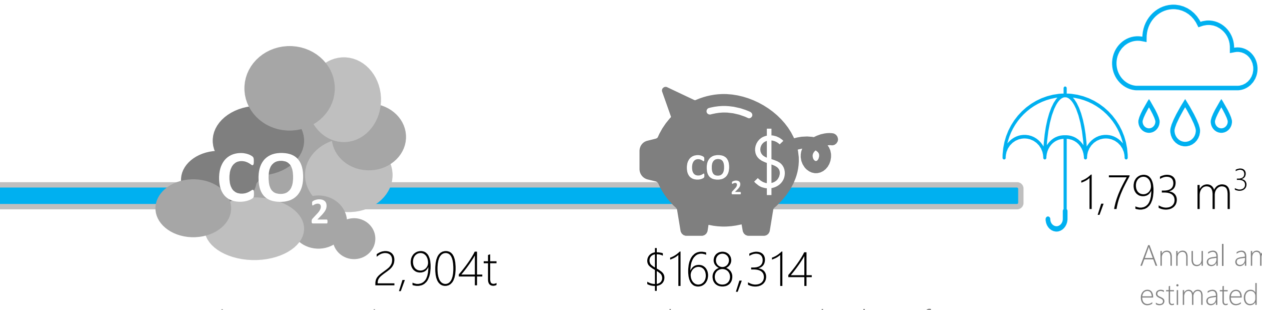
The site has important historical and cultural values, with Hikanui Pā being present within site. The site sits within an urban community of varied topography with a range of paths and a bike track. Considering the growing body of research that shows exposure to trees and green spaces improves wellness and sociability (Wolf and Robbins 2015), the site, with its accessibility, canopy coverage, and cultural value, is of great importance to the community. Additionally, both sites provide community partnerships (e.g. planting), which have significantly increased amenity value in both areas.

2.8.2 Negative wellbeing and amenity effects

The exotic plantation trees planted on and around the pā site significantly detract from the site's heritage value. Additionally, the heritage value and the connection of the surrounding landscape provides in terms of sense of place also cannot be understated.

2.9 *Environmental values of the captured trees*

The environmental values of the trees assessed are estimated as follows



The estimated amount of carbon stored

The estimated value of the carbon stored

Annual amount of water estimated not to hit the ground, reducing stormwater runoff

In terms of carbon sequestered, this, in most instances, would be reduced due to the life stage of many of the mature trees. Both carbon stored and rainwater intercepted would be decreasing due to failures and foilage densities reduction (eucalyptus). But if no intervention was carried out, this is likely to be replaced by invasive vegetation (e.g. pine and wattle).

This section analyses the data to identify risks and opportunities (beyond general tree management recommendations) to ensure the urban ngahere is sustainable and resilient.

3.1 *Tree risk*

Reducing the risk of harm to people and property will always be a priority, but consideration is given to limit intervention works to allow the retention of trees with realistic potential to contribute to other important objectives such as enhancing ecological diversity, conserving heritage value, sustainable management and optimising canopy cover. Further information on tree risk and how it is assessed is provided in Appendix 1.

3.1.1 Both sites would be best described as natural recreational spaces for walks and limited access for mountain bikers. Estimated occupancy for Tainui and Tauroa are as follows:

- **Tainui**
  Folkl people count (April 2021): Average 104 people over an 8hr period (weekday) 207 people in the weekend. 34 cyclists during an 8hr period and 136 in the weekend
- **Tauroa**
  PS maximum people count over an 8hr period (24.07.21): 40 people and 10 cyclists (weekday)

Refer to appendix 1 for more details on estimated occupancy for both sites.

Tainui has a number of walking tracks; therefore, the entrances into the site have occupancy levels that sit at the higher end of the occupancy spectrum (moderate to high), whereas the rest of the site and Tauroa would have occupancy levels in the lower end of the occupancy spectrum (moderate to low).

3.2 *Occupancy during storm events*

High wind events play a critical role in the frequency of tree failure. As the reserve is used purely for recreational use, occupancy during a storm event is expected to reduce. Tree failure is evident in both sites, and to my knowledge, there have been no near misses recorded, which suggests the reserves are mainly empty during these events.

3.3 *Risk of harm occurring from a tree-related failure*

HDC has been carrying out proactive works to increase safety factors by removing problematic trees and inspecting trees after storm events. Additionally, the Council react to concerns raised by the public. The combination of proactive works and the site's general low occupancy during storm events means the risks are currently being controlled and are low.

3.4 *Risk of damage to structures*

All trees along the boundaries were checked, apart from an area that was inaccessible (a small parcel of land adjacent to Keith Sands Grove where trees were viewed from the nearest access point). No obvious defects were viewed in any of the boundary trees.

3.5 *Current risk management of trees*

Current risk management carried out by HDC is reasonable and proportionate to the current risks. Further recommendations are made in section 4 to ensure the trees are sustainably managed.

3.6 *Risk of degradation of historical sites and cultural wellbeing*

The below image highlights the trees that surround the peninsula where Hikanui Pā is located (centrally within the red highlighted area).

Fig 12 Red area indicates Tree Group 1, the area around the pā site. This area contains 266 trees (almost entirely consisting of pine and macrocarpa. Fig.13 shows the area highlighted with the white circle

Fig.13 Image of the edge of pā site taken looking north. The red area highlights the edge of the red group, as shown in Fig.12.

3.6.1 As highlighted in section 2, the stand of trees are becoming open and more susceptible to windthrow (as can be seen in Fig.13; trees removed due to structural defects the stand is becoming more open).

3.7 *Options to mitigate damage to pā and cultural wellbeing values.*

3.7.1 Trees could be pruned to"windfirm" (reduce sail areas to increase safety factors of trees to withstand strong winds). This would reduce the likelihood of tree failure but would be a very costly management option. Additionally, this would not address the planting of forestry trees on a site of cultural significance.

3.7.2 Due to the stand condition, as previously discussed, removing part of the trees would only increase the risk of windthrow. Given the tree conditions, the history of failure, the topography of the site and its cultural significance, the only logical option is to remove the stand of the trees on the pā site entirely.

3.7.3 This option would have short term adverse effects in terms of environmental and amenity loss but provides improved long term gains in terms of environmental and wellbeing benefits. Additionally, the removal supports current works to convert the site to a permanent native forest stand.

3.7.4 Removal of the trees on the pā site would also necessitate the removal of trees within the gulley area (seen standing on the left of the image in Fig.13). During a removal operation for the pā site, it would also be logical to remove some outlier pine trees adjacent to the site. Other trees proposed for removal are to support long-term management aspirations (e.g. removal of invasive seed source).

This approach would eventually involve the removal of 514 trees:

- Tainui 433 trees
- Tauroa 81 trees

Reasons for removal are shown on the graph to the right and location of trees for removal are shown below.

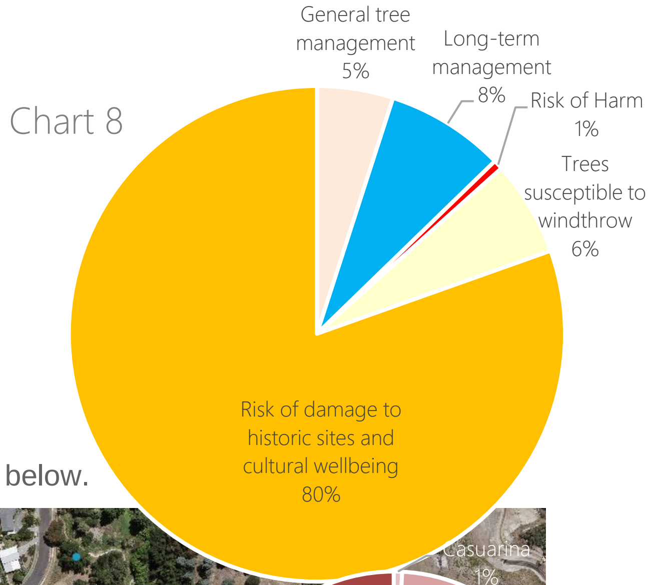
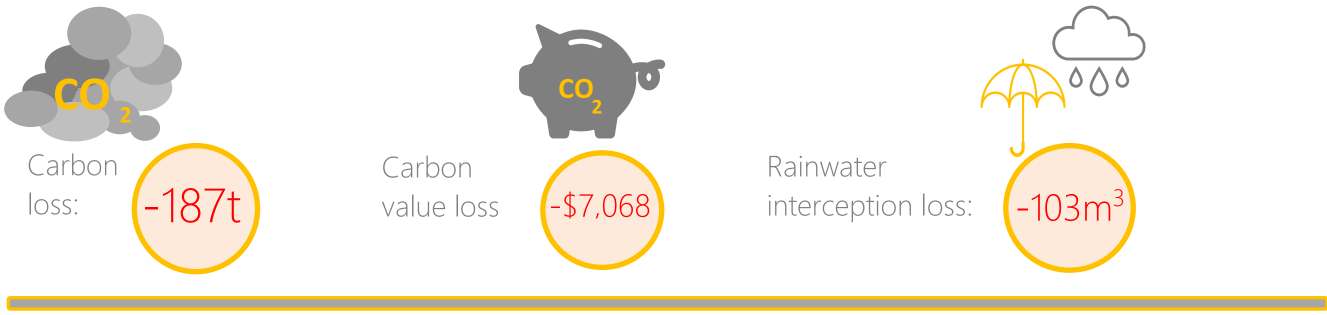


Fig.14 Map of trees for removal, colour coded to the management principle and shown as percentages in chart 8. Chart 9 shows the species to be removed as percentages.

3.7.5 Loss of environmental benefits from proposed removal



3.7.6 For the environmental effects to be mitigated, climax native forest species will be needed (i.e. trees that can reach 30m). The aspiration on both sites is to revert the forestry stands largely back to a native podocarp stand.

3.7.7 In terms of environmental loss, it's important to stand back and look at it in context. Currently, pine and macrocarpa dominate the site. Due to their rapid growth rate, they will always outcompete native trees in the short term. It may take a couple of hundred years for a native tree to sequester as much carbon as a pine tree can in 30yrs.

3.7.8 However, there are limitations with such rapid growth rates, such as can be seen on site by the number of failures where trees are becoming more susceptible to wind damage. When a tree falls, the majority of the carbon stored is released back into the atmosphere and is lost. Carbon sequestration plateaus as a tree reaches full maturity. Most of the trees within the site are considered to be at or near that life stage.

3.7.9 Given the site and the conditions of pine and eucalyptus its not considered that these would be long-lived within the site. Therefore, converting the site to a primarily native forest with long-lived climax species would yield far greater long-term environmental benefits.

3.7.10 Cultural wellbeing

The removal of exotic plantation species and the increase of native flora could only improve cultural wellbeing. Additionally, the pā site would become a focal point and a place of community learning. This, combined with the restoration works and ongoing community partnerships, provides fairly significant across-the-board wellbeing gains.

3.7.11 Schedule for removal of large scale works

In terms of scheduling tree removal, the removal works should take place as follows, with items 1 and 2 completed in the next 12 months and item 3 within the next 12-24 months. Item 4 should be scheduled as required. It should be noted the timeframes are a recommendation and do not represent a time when items will become unsafe if works are not carried out within the recommended time ranges. Below is the priority, from 1-4 in which the works should be carried out:

1

Risk of harm (2 trees)

Trees marked for risk of harm to be removed at the earliest convince. These trees are not an immediate risk but a risk that is emerging in areas of moderate to high.

2

General tree management (16 trees)

These are either small invasive trees in newly planted areas or dead trees that stand adjacent to tracks but are not degraded enough to be considered a risk as yet. Dead trees are recommended to be made safe, so truncated where practical to maintain habitat.

3

Tainui Risk of damage to historical sites and cultural wellbeing (259 trees)

These should take place only once all mitigation measures are in place, especially for replanting. Due to the site's sensitivity, mitigation plants (i.e. trees that reach large dimensions) need to be planted elsewhere.

Tainui Trees susceptible to windthrow

These trees would need to be removed as part of the above works. There is likely to be further failures in retained trees that are left, and therefore, the removal of adjacent edge trees needs to be adaptive based on the site conditions as predicting the change in wind loads is not currently possible.

Tainui Long-term management

It makes logical sense to remove pine outliers if any large scale tree removal is to take place within the reserve

4

Long-term management (81 trees)

Tauroa

Continue to remove pine groups. Liaise with care group on timings prior to any removal to help plan and prepared for replanting.

3.8 *Other tree works on sensitive areas*

A pine tree stands on an area of historical significance. The tree is a large pine that is an edge tree that provides buffering to the trees on the exposed hillside (see fig.18).

Failure of limbs is apparent within the tree, which is a common failure trait in pine. The tree exhibits apical dieback but is in good health, so it is considered to be in a retrenchment life stage. R eduction of limbs is proposed to minimise limb failure and retain the tree as a buffer.

Fig.18 location of T528

3.9 *Planting*

3.9.1 Revegetation plantings have been carried out in both sites over the years with Tauroa, where the care group have almost a 100% plant success rate. Tainui is a harsher site for plant establishment. Here the council and care group partnerships have begun establishing pioneering species to provide canopy cover for climax species. Additionally, climax species are and have been planted within areas of existing exotic canopy coverage.

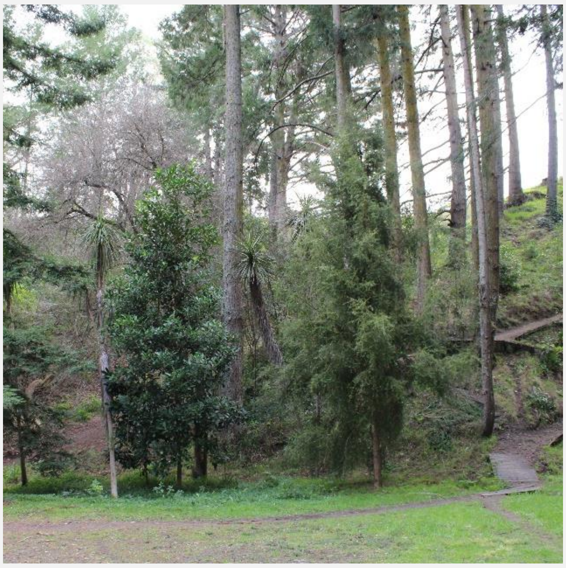


Fig.15 Image on the left showing established planted karaka and totara (Tainui), and image on the right showing established puriri (Tainui).

Fig.16 New plantings by care group in Tauroa

3.9.2 Removal of the trees from the western bank of the pā site is likely to result in some slips forming, and mitigation of low lying planting should be considered as a priority in these areas.

3.9.3 Considering the constraints around the heritage site, mitigation for the removal would need to be carried out elsewhere in the site, which can continue to bolster existing and ongoing planting efforts. There are plenty of opportunities to increase biodiversity and introduce further seed sources within the reserves. Continuing planting exotic trees in areas of the reserve should also be considered to maintain a seasonal food resource for birds such as kereru and tui.

Fig.17 Image on the left showing Tui feeding on Taiwanese cherry flowers. The image on the right showing two kereru roosting in a swamp cypress

3.9.4 For any ecological restoration works to mitigate the environmental impact and offer improved long-term benefits over the current tree stock, climax species capable of reaching a height of 30m would need to establish successfully. Most of these climax species are mutualistic and require a closed canopy for successful establishment. Water availability and climate change may also be other limiting factors. Therefore, an ecological restoration expert should be engaged. This is to ensure the appropriate monitoring and guidance can take place so that climax species can establish and native areas become sustainable margins.

3.9.5 <u>Herbicide use</u>

There are a number of areas within the site where chemical damage has lead to the death of new plantings. Therefore, chemical management needs to be strictly controlled or alternative measures put in place. Such management within the reserves will adversely affect sustainable outcomes if not controlled.

This section provides the final management recommendations based on the analysis of the previous sections.

4.1 *Management works*

4.1.1 All Management works are to be discussed with the operation manager to ensure all works details are understood in terms of works and risk requirements for the next 3yr period.

4.1.2 Tree works should be prioritised as set out in the management programme (excel spreadsheet) and for large scale works as outlined in section 3.9.

4.2 *Risk management*

4.2.1 HDC to maintain regular checks throughout the year and after storm events by employees and contractors. The type of check must be a walked visual check looking from accessible viewpoints for obvious defects from a distance and close-up. Should the visual check identify areas of concern, a detailed inspection should be carried out by competent personnel with enough training and experience working with trees to identify obvious and subtle defects and recommend how to manage them.

4.2.2 This regime should be supported by periodic inspection by a suitably qualified arborist with suitable training and experience in risk management. The arborist is to provide recommendations and critically analyse the advice and recommendations received from other tree contractors and arborists for any risks under current controls.

4.2.3 Failures that do not cause harm or damage provide a useful opportunity to identify opportunities to improve the management system and inform further recommendations based on intelligent analysis. Therefore its recommended that a system is established that records the following information:

- Trees that failed and types of failure.
- Date and time when the failure occurred.
- Weather event at the time of failure.
- Any notes and images by the contractor on failure.
- Notes on what action was taken and any recommendations.

This information can then be used to inform current and future management decisions and provide a documented account of how the risks are being pragmatically managed.

4.3 *Partnerships*

4.3.1 Promote and connect care groups to foster shared learnings between the two reserves. Seek opportunities to partner and build public interest for planting days with schools, iwi and others to assist community groups and help build those groups to be sustainable. Consider taking an innovative approach to engaging the community, such as planting days that could be run alongside mountain bike workshops etc.

4.3.2 Any further removal of pines within Tauroa should occur in consultation with the care group so they can direct works to facilitate the planting works and prepare ahead of time for planting once the trees are removed.

4.4 *Revegetation works*

4.4.1 Continue with existing objectives to support indigenous revegetation works. Ensure restoration works are planned so that they can connect to other landscape sites and individual restoration sites. Development should give consideration to how other sites and remnant areas can complement the works.

4.4.2 Continue to support community champions and review engagement to look for any improvements.

4.4.3 Seek to support these groups for growth so they can become more sustainable beyond the core group.

4.4.4 Create and transfer shared learnings between groups, and provide connection network opportunities between groups if this does not already occur.

4.4.5 Engage a restoration ecologist to ensure successive native tree establishment takes place.

4.4.6 Maintain planting of exotics to provide a seasonal food resource for birds such as tui and kereru.

4.4.7 Control or preclude chemical control (spraying) within the reserves. Spot treatment should still be considered (e.g. poisoning of stumps), but any such works should be strictly controlled and monitored. Establish and maintain a public herbicide register for any chemical agents used within the reserve.

4.5 *Next arboricultural inspection*

Reinspect trees in 3 years.

This section reviews the recommendations against relevant SDGs to ensure management action promotes sustainable action to protect and enhance the urban ngahere.

5.1 Sustainable development goals

5.1.1 The recommendations within this report are a continuation of the current management objectives. HDC has been progressively removing plantation species and has supported replanting. Removing large stands of vegetation presents challenges, especially for successfully mitigating the loss. However, this is where there is considerable opportunity to improved landscape resilience and wider community connection.

5.1.2 The greatest challenge is successful plant establishment, and in Tainui this is large scale works. The current success of the replanting is down to the partnerships with community groups. The success rate for the plantings is a testament to the dedication of the individuals who provide time and energy for creating future benefits for generations to come (see figs 20 and 21).

Fig.19 Ria Oosterkamp, community champion, part of the Tauroa community planting group along with Michelle Hicks and Howie.

Fig.20 Establishing matai (*Prumnopitys taxifolia*) under the aftercare of the community group in good health in Tauroa Res

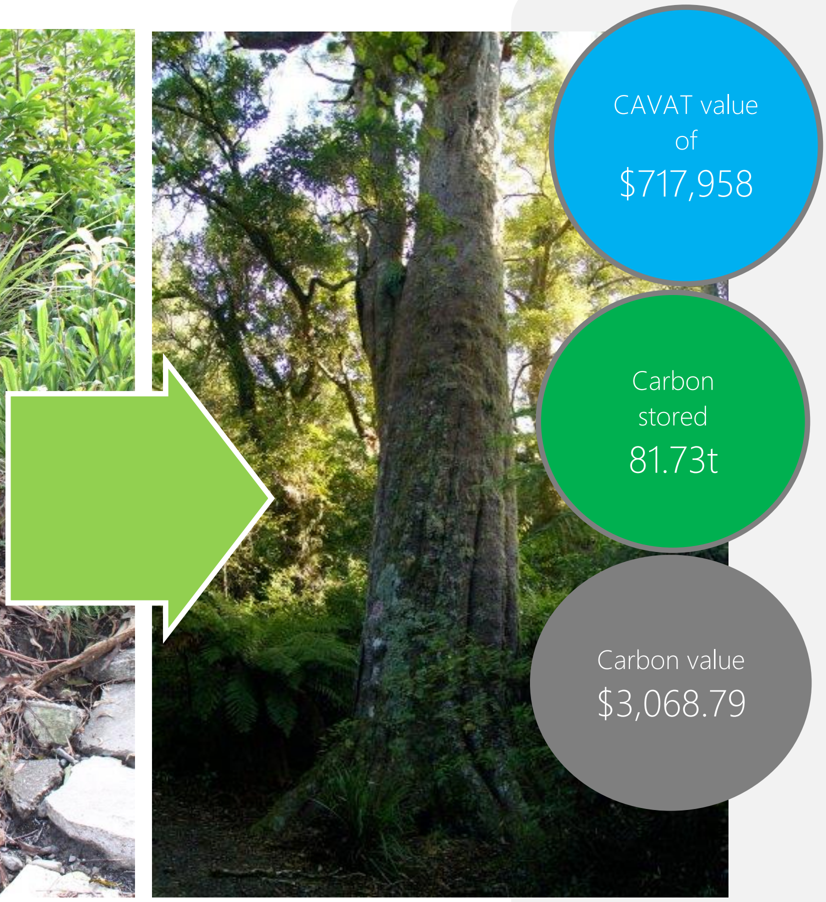


Fig.21 700yr old Matai tree located within the Boundary Stream Scenic Res, Tutira, Hawkes Bay. (Notable Tree Trust image by Matt Smillie)

5.1.3 Above highlights the potential value creation that the community groups are providing.

5.1.4 Overall, the proposed works are part of a progressive plan that is in the process of changing a landscape and providing greater protection for sites of significance. The works provide increased opportunity for connection to place, community engagement and improved long term environmental benefits.

RICHIE HILL

EST. PS 2013

APPENDIX 1 TREE RISK DETAILS

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The following information sets out how Paper Street (PS) assesses risk and inspects the trees. The appendix has been divided into three sections so the reader can view the section relevant to their interest:

Part one

This section outlines the background and provides the basis of tree risk management. This is to provide some context to a subject that can create a lot of uncertainty and subjectivity. This section also contains current (at the time of the report) guidance. PS risk management recommendations and strategies are continually reviewed during each project, based on updated information and site specifics. To this end, PS does not use or subscribe to a "risk method" as such methods offer limitations in implementing improvements in assessment processes. It should be noted that risk methods can improve certainty for practitioners with inexperience, high uncertainty, or who are in general risk-averse by nature. Such tools can aid decision making for experienced practitioners for comparative analysis, should such analysis be required.

Part Two

Sets out PS inspection process.

Part Three

Provides additional information on PS tools used to facilitate risk analysis.

Part one

P1.1 ***Introduction***

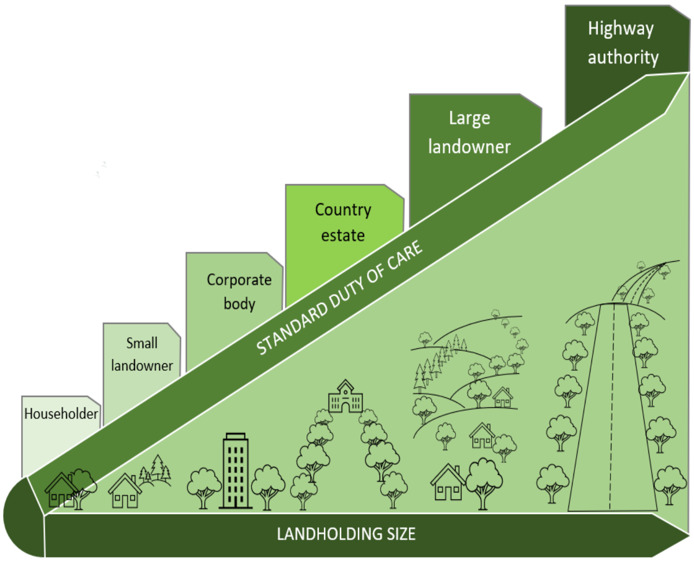
Although trees can be a liability, there is a growing research base documenting the benefits that arise from the close integration of trees with society. Those benefits are many, including buffering heat extremes, reducing heating and cooling costs, slowing rainwater runoff, ecological enhancement, air pollution reduction, carbon sequestration, increasing property values, conserving living cultural connections to the past and future, visual enhancement, and improving human health and wellbeing, to list the most obvious.

P1.2 For communities to make the most of these benefits, trees must be close to where people live and work, so spread evenly across the built environment. Urban trees are most useful when growing alongside roads and other transport routes, close to buildings, in gardens, and throughout urban recreational spaces. Unsurprisingly, there is a strong link between tree size and the number of benefits received. Although the precise relationship will vary from species to species, the amount of benefit is significantly influenced by the three-dimensional crown volume, which is a reliable proxy for leaf area, rather than the two-dimensional area projected beneath the branch spread. This results in an exponential relationship between tree size and benefit delivery, so big trees are significantly more useful than small trees.

P1.3 However, trees are natural shedding organisms. This natural process can lead to potential damage or harm to occur where trees are located adjacent to areas of high occupancy. Within this context, management recommendations need to manage those important community benefits whilst minimising the likelihood of harm or damage occurring.

P1.4 *Legal requirements*

In the civil context, a duty holder carrying out a business or undertaking has obligations under the HSWA, as far as reasonably practicable, to prevent and minimise foreseeable harm or damage occurring from trees that are under their ownership and control. A good way to visualise the level of care from a duty holder is on the adjacent graph (Graph 1).



Graph 1 Duty holder level of standard of care

P1.5 *Risk management*

In the broader management context, risk is defined as the:

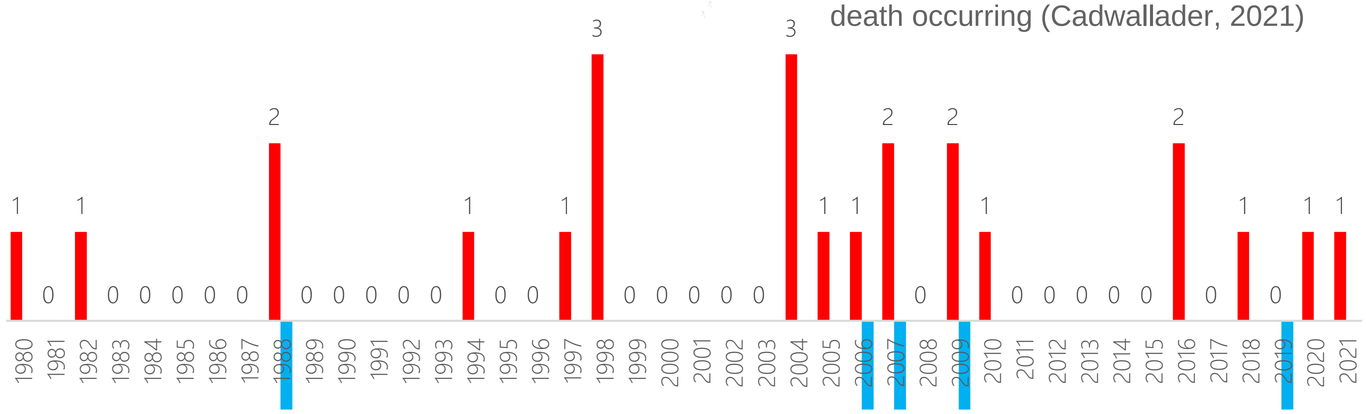
> *"effect of uncertainty on objectives"*
>
> (AS/NZS ISO 31000:2009 and ISO 31000:2018)

The effect is a deviation from the expected (positive and/or negative). As trees provide multiple benefits, action or management could control one risk but adversely affect another objective if the risks are not assessed in context (HSWA).

P1.6 *Perceptions of tree risk of harm occurring*

Before determining the risk of harm, it is important to establish the risks to ensure any guidance recommended is proportionate and reasonable.

Unpublished research currently identifies that over a 41yr period, 25 deaths have occurred in NZ due to a tree-related failure. This equates to around 1:7 million chance of a tree related death occurring (Cadwallader, 2021)



Graph 2: Number of fatalities in the 41yr period. Blue lines indicates when an inquest was carried out. Risk assessment methods introduced; Matheny & Clark (1993), QTRA (2005), TRAQ (2017) and VALID (2019)

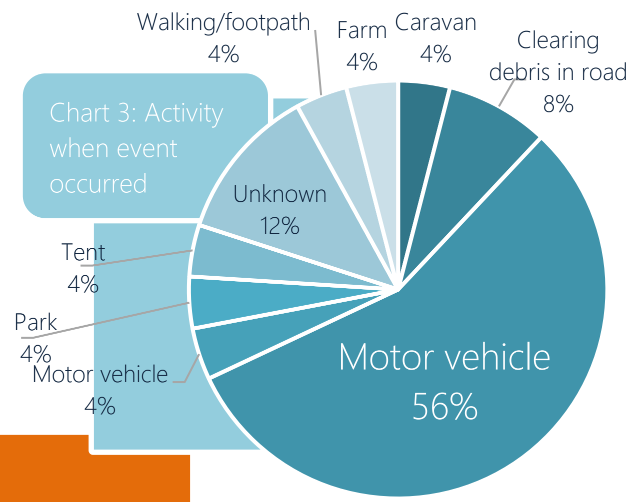


Chart 3: Activity when event occurred

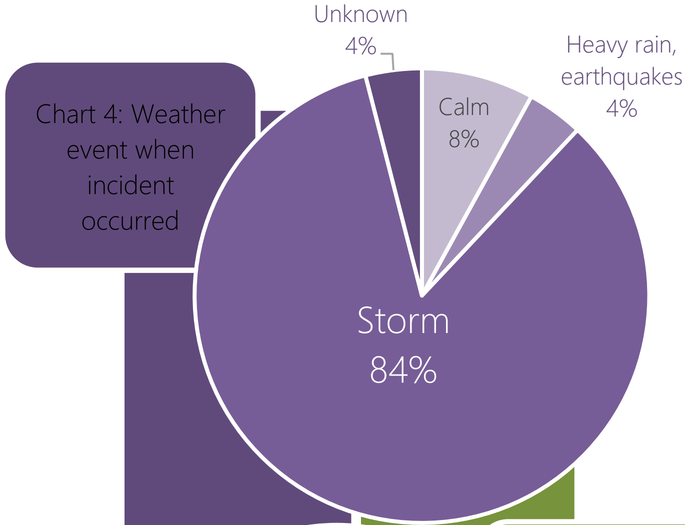


Chart 4: Weather event when incident occurred

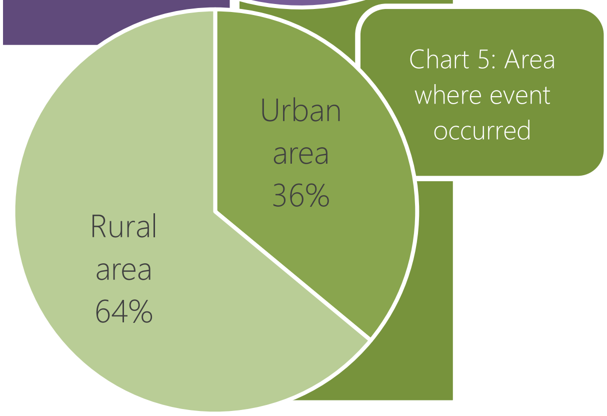


Chart 5: Area where event occurred

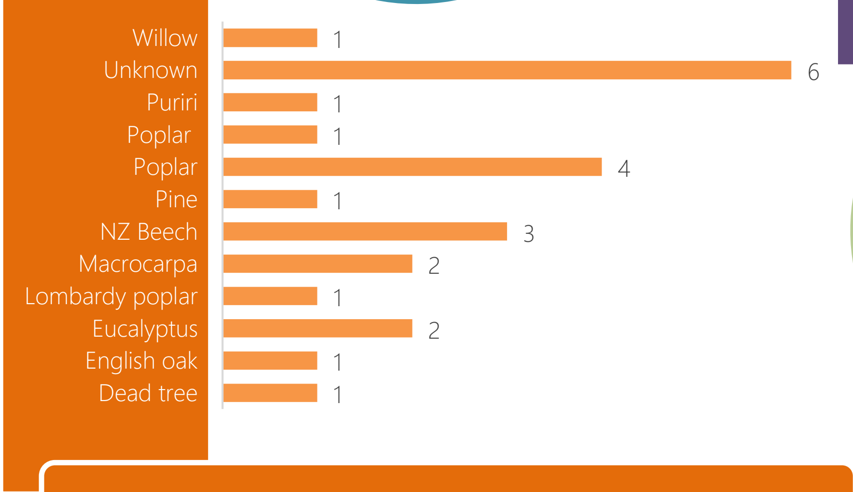


Chart 6: Species that failed

P1.5 *International statistics*

In Australia, research works carried out found that over 168yr period 280 deaths occurred, equating to a 1:4million chance (Hartly 2019). In the UK, the research identified 64 deaths in a 10-year period equating to a 1:10million chance (NTSG, 2011). In the US, the research identified 407 deaths in a 13yr period, equating to a 1:11 million chance (Schmidlin, 2008). To put that into some form of context, fatalities resulting from driving in NZ over a 1yr period (2019-2020) equated to 1/14 thousand chance. In the absence of having national guidance on risk thresholds, the HSE (UK) classed any risk below 1:1 million as being broadly acceptable, in other words;

> *"the levels of risk characterising this region are comparable to those that people regard as insignificant or trivial in their daily lives" (HSE, 2001),*

This would, in the broadest context, define trees as being very low risk.

P1.6 *Perception of risk and biases*

The overall risk from trees may be low, but our perception can be strongly influenced by media showing images of limb/tree failures after high wind events (NTSG, 2011).

Fig.2 Image from a recent storm in Auckland (03.08.21) RickyWilsonStuff.co.nz

This can influence our perception and can create a strong bias towards risk aversion. Trees are complex, and there are many unknown variables in predicting when a failure event may occur. This can create a lot of uncertainty, even within a tree "risk assessment". The personal bias and experience of the assessor and decision-maker have a greater influence on a risk rating than the tree itself (Koeser,2017). However, it is very important to acknowledge the differences between the broad concept of risk, which, as highlighted above, is generally low, and the localised potential for risk, which could be high. Taking a minimal invention approach, therefore, is highly unlikely to be defendable in the localised context, e.g., a dead tree overhanging a high occupancy area will always be a high risk, not a low one. This could be why we see that only 36% of fatalities happen in urban areas (which are of higher occupancy) as risks are more likely to be proactively managed there.

P1.7 *Calculating tree risk*

Determining the failure of a living structure that is constructed of a dynamic material such as wood is an imprecise undertaking. Currently, there is not enough data to reliably calculate tree risk (Matheny, Clark, 2009). As previously mentioned, the perception of risk, acceptance of risk, and an arborist's professional bias and their experience have more influence over the final risk determination than the actual tree assessed (Norris 2007; Koeser and Smiley 2017). This can lead to a wide range of opinions and mixed "risk terminology" and risk methods from arborists;

> *"Unfortunately, consistency (while an important aspect of making risk assessment more reproducible) is not the same as accuracy. Variability in ratings means some portion of the assessments will be inaccurate. However, false precision in a risk assessment method could create a very consistent bias that pulls the perceived level of risk away from the actual level of risk for all who subscribe to the method."*
> (Koeser 2016)

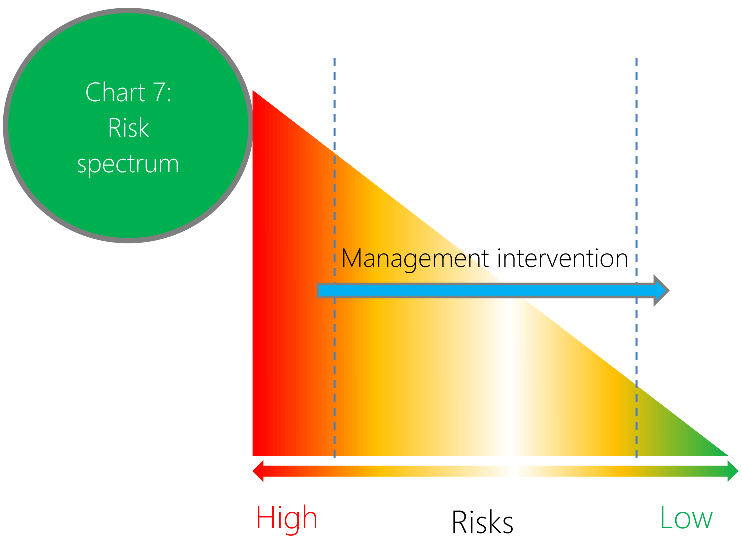
Therefore, the experience and objectivity of an assessor are critical if a proportionate management intervention is to take place.

P1.8 *Identifying a tree risk*

In risk identification risk can be simply expressed as risk = potential events, the consequences, and their likelihood (ISO 2009, 2018). Simply put for trees, for a tree to be considered a risk it would need to exhibit signs of foreseeable failure (Potential Event) standing in an area of sufficient occupancy (Likelihood) where a person is likely to be beneath the weak point when a failure occurs (Consequence). The likelihood of impact occurring strongly correlates to occupancy, and whether a tree exhibits a defect where failure is foreseeable within an inspection period. Therefore, a tree has to have a foreseeable failure within a high occupancy area for it to be a high risk. Conversely, a tree with foreseeable failure in an area with little occupancy would be of low risk.

P1.9 *Taking a tree-oriented approach*

For a decision-maker to understand tree risk is to conceptualise tree risk on a spectrum where risk is either increasing in one direction or the other. It is not possible to pinpoint the level of risk due to each site and a tree's condition being different, but it can be described as sitting on one end of the spectrum or the other. For example, a large tree with a significant defect in a high occupancy area could be described as sitting at the higher end of the risk spectrum, and the intention of management interventions would be to shift it towards the lower end (Barrell, 2020).



Part two

P2.1 ***How PS inspects the trees***

Trees are inspected from ground level using binoculars where necessary. A visual criterion is used to assess the mechanical integrity of the trees[1,2]. If a defect is identified that has a foreseeable chance of harm or damage occurring, the tree and all necessary information is captured. Additionally, a sounding hammer is used to aid detection of any extensive decay within the stem buttress zone or bases of roots, should such an investigation be warranted. Trees are assessed in consideration to the weather events to which they would be typically subjected and the environment in which they stand.

P2.2 All inspections are GPS tracked to provide a record of where the inspections were carried out.

P2.3 Reducing the risk of harm to people and property will always be a priority, but consideration will also be given to limit intervention works to allow the retention of trees with realistic potential to contribute to other important objectives such as enhancing ecological diversity, conserving heritage value, and optimising canopy cover.

P2.4 Intelligent tree management interventions are applied to the recommendations so as not to just focus on managing the risk from tree failures, but also to be sensitive to the wider implications, so careful, considered, and balanced outcomes can be reached.

P2.5 ***Inspection periods***

All assessments of risk are set against an inspection interval. Inspection intervals are determined during each assessment based on the condition of the tree being assessed. As tree condition is dynamic, so needs to be the inspection interval. Each inspection interval is based on trees being checked by contractors who can identify a significant defect that has the potential to cause harm after storm events. Additionally, works/inspections are carried out after a service request is raised by the public (e.g., a member of the public contacts the council to report a fallen tree).

Part three

P3.1 ***Additional details***

Additional analysis is carried out where necessary if risk falls outside of common-sense management (i.e. large hanging limb over a busy path) to support recommendations. Below are the methods PS used to assist in the analysis of the risk where there are no measures to use:

P3.2 ***Occupancy***

To determine or measure the likelihood of impact as a consequence of a limb failure, a person or target needs to be beneath. Occupancy, or the duration in which something is underneath the tree or tree part assessed to fail, is a significant factor in determining the risk of harm occurring. Therefore, for it to be considered high risk, a tree needs to show foreseeable failure where failure would occur over a high enough occupancy area for the likelihood of a person to be beneath it when it fails.

P3.3 Occupancy could also be viewed on a spectrum, with high and low being at either end and the area between being harder to distinguish in terms of where one classification stops and another begins (e.g., low to moderate occupancy). Currently, there are no standards or classifications for how many people equal a low, moderate or high level for site occupancy. For this assessment, any defect that has around 3% of occupancy beneath it (45minutes a day of permanent occupancy) is used as a benchmark as the start of the higher occupancy end of the spectrum.

P3.4 ***Calculating occupancy***

People counts are factual measures and can assist as a base level for occupancy within a site. During a PS survey, people counts are manually recorded. Additionally, Folkl carried out a people count for Tainui reserve during autumn:

- **Tanui**
  Folk people count (April 2021): Average 104 people over an 8hr period (weekday) 207 people in the weekend. 34 cyclists during and 8hr period and 136 in the weekend

- **Tauroa**
  PS maximum people count over an 8hr period (24.07.21): 40 people and 10 cyclists (week day)

P3.5 The time of year strongly influences people counts, especially for most park sites when inspecting trees in the winter months, as site use is generally at its lowest.

P3.6 People counts are becoming more common, and reviewing data for certain areas with annual counts can provide meaningful information on anticipated seasonal change and likely reductions during storm events. Chart 4 shows that 84% of all recorded fatalities in NZ have occurred during high wind events. Knowing that occupancy is much reduced in storm events is therefore important. Historic people counts show reductions in occupancy during those times, apart from CBD areas or commuter routes which show minimal reductions.

P3.7 I have not been able to source annual people counts information for parks in NZ yet. Therefore, data used from Central Park in New York City is used to provide an indication of anticipated human behavioural patterns for seasonal fluctuations for storm events. Below are the estimated data on people counts based on site recordings and on information provided by Folkl, and for Tauroa based on site counts.

Estimation of occupancy Tainui

Site description:	Public open space	Season decrease	% of total value remaining	Estimated weekend increase	Estimated weekend Occupancy
Season counted:	Autumn	32%	68%	84%	197
Max occupancy recorded	107		Estimated average week occupancy:		133
Seasons:	Summer	Autumn	Winter	Spring	
Est. seasonal decreases from high occupancy season (%)	0%	32%	65%	22%	
Estimated daily seasonal ave considering % seasonal changes:	195	133	68	152	
Est. annual daily occupancy mean:	142	Ave walking speed (m/s):	1.3		
Storm reduction:	46%				

Estimation of occupancy Tauroa

Site description:	Public open space	Season decrease	% of total value remaining	Estimated weekend increase	Estimated weekend Occupancy
Season counted:	Autumn	32%	68%	84%	74
Max occupancy recorded	40		Estimated average week occupancy:		50
Seasons:	Summer	Autumn	Winter	Spring	
Est. seasonal decreases from high occupancy season (%)	0%	32%	65%	22%	
Estimated daily seasonal ave considering % seasonal changes:	73	50	26	57	
Est. annual daily occupancy mean:	53	Ave walking speed (m/s):	1.3		
Storm reduction:	46%				

P3.8 ***Putting occupancy into context***

Occupancy is considered over a 24hr period. Occupancy is difficult to determine with accuracy due to the unpredictability of public movement. Additionally, people often move in groups which can be influenced by peak flows and not equally spread out. Nonetheless, justification needs to be reached as to why a site is defined as low or high occupancy. To provide a base indication of occupancy, the size of each defect (estimated base dia, length and width) is recorded to estimate the duration in which a person may be beneath the part deemed to fail. The largest measurement is then used, and the average walking speed of 1.3 meters a second is used, to estimate the duration a person may be beneath the part. The weight of the defective part is also estimated based on cylinder and wood density to indicate force. Road volumes are also considered, with speed limits and annual average daily traffic counts based on road type, provided by NZ Transport Agency.

P3.9 Additional details are also considered where occupancy levels are reduced based on site usage e.g., a tree at the periphery edge of a park would have less of the site occupancy than the main path. Additionally, public generators are considered, such as seats with estimates of site duration.

P3.10 *Storm events*

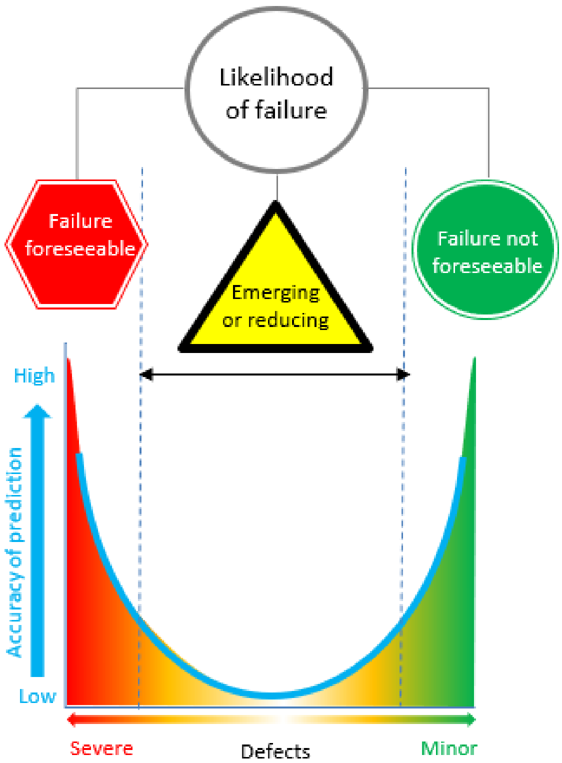
If a defect is identified, it is then assessed if the likelihood of failure will occur in a storm event or at any time. If a defect is considered to fail in a storm event, then the estimated occupancy is reduced by the estimated % taken from other site data of occupancy reductions during storm events.

P3.11 *Assessing the likelihood of failure*

Predicting the likelihood of failure is difficult to determine with a high level of accuracy. There is limited research to show the validity of arborists assessments for the likelihood of failure. What limited research there is suggests that unless a defect is severe, it is unlikely to increase the likelihood of a failure.

Research carried out during a high wind event used 673 trees, which were risk assessed by three experienced, trained practitioners and then revisited to assess storm damage. Trees were rated qualitatively where imminent was the highest likelihood of failure followed by probable, possible and improbable. The study found:

- 94.1% of trees that had an imminent rating failed.
- 38.8% of trees failed that were rated as probable.
- 15.3% of trees failed that were rated as possible.
- 0% of trees failed that were rated as failure being improbable.



The study highlights the less obvious a defect, the greater the uncertainty of predicting the likelihood of failure. Therefore, unless a defect is obvious it is unlikely to be reliably assessed as foreseeable. The greater the uncertainty for failure the more inaccurate the determination, which has implications on management actions if wide ranges of terminologies are used.

Therefore, each defect is rated as:

- Imminent: an event that is predicted to occur at any moment
- Foreseeable: an event that a competent inspector would consider as likely to occur within a checked period
- Emerging: an event which may take place within a checked period, but the significance of the defect is considered to increase over time
- Controlled: for defects being actively controlled where further controls may be necessary
- Further analysis: areas where further analysis is required to evaluate the risk.

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